THE AQUATIC PLANT COMMUNITY OF ARKDALE LAKE, ADAMS COUNTY, WISCONSIN

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I. INTRODUCTION

A field study of the aquatic macrophytes (plants) in Arkdale Lake was conducted during August 2005 by a staff member of the Adams County Land and Water Conservation Department. Results were shared with the Wisconsin Department of Natural Resources. This was the first aquatic plant survey of any kind done in Arkdale Lake.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information necessary for effective management of Arkdale Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This baseline data will provide information that can be used for comparison to future information and offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Background and History: Arkdale Lake, in Adams County, is a 56 surface acre impoundment of Big Roche-a-Cri Creek. The drainage basin area is 142 square miles. Arkdale Lake lies downstream from Big Roche-a-Cri Lake, between that lake and the Wisconsin River. It has a maximum depth of 8', with an average depth of less than 5'. There are two public boat ramps, one on the south side of the lake and one on the north side of the lake.

The first dam was built in 1960 to provide power for a grist mill. The dam was rebuilt in 1966 after a dam break on 4/3/65. The flow gates of the dam are owned by the Arkdale Lake Association. The part of the dam from the flow gates south is owned by the Old Mill Bar. The part of the dam from the flow gates north is owned by the Pouska family.

Much of the area between Big Roche-a-Cri Lake and Arkdale Lake is wetlands that serve as filters for some of the input towards the lake. Soils in the watershed are mostly sand and loamy sand. Predominant land use in the surface watershed includes irrigated and non-irrigated agriculture and residential development. Most of the residences around the lake do not have buffers of 35' or more. The east end of the lake has accumulated so much sediment that places are not passable even by canoe.

The Arkdale Lake Association owns a small mechanical harvester. Mechanical harvesting has been performed on a sporadic basis since 1966 without any particular schedule or map. Records indicate that no lakewide chemical treatments have occurred since 1968-1971. There was a DNR-approved drawdown in the spring of 1988 to attempt to control aquatic plant growth. Lake-front owners noticed no particular decrease in aquatic plant growth; however, they noted a considerable increase in silting in the lake and a negative effect on the fishery from the drawdown.

The Wisconsin DNR determined, in 1971, that the lake was best managed for northern pike, largemouth bass and panfish. Inventories going back to 1935 show a good mixed fishery, although fish were removed at the DNR's request in 1989 after stunted panfish were found during a 1978 fishery inventory. The most recent fishery inventory of Arkdale Lake showed that northern pike and white sucker were abundant; yellow perch, black crappie and bluegills were common; spotted sucker and pumpkinseed were present; largemouth bass and walleye were scarce.

II. METHODS

Field Methods

The study was based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 12 equal sections, with a transect placed randomly within each segment, perpendicular to the shoreline.

One sampling site was randomly chosen in each depth zone (0-1.5'; 1.5'-5'; 5'-10') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was abundantly present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. (See Appendix A) Relative frequency (number of species occurrences/total all species occurrences) was also determined. (See Appendix A) The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. (See Appendix B) Relative density (sum of species' density/total plant density) was also determined. (See Appendix B) Mean density where present (sum of species' density rating/number of sampling sites at which species occurred) was calculated. (See Appendix B) Relative frequency and relative density results were summed to obtain a dominance value. (See Appendix C) Species diversity was measured by Simpson's Diversity Index. (See Appendix A)

The Average Coefficient of Conservation and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of conservation is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservationism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

An Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Arkdale Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. Impoundments with over 30 ug/l phosphorus are likely to be subject to nuisance algal blooms. **The 2004-2005 summer average phosphorus concentration in Arkdale Lake was 34.085 ug/l.** This concentration suggests that Arkdale Lake is likely to have nuisance algal blooms.

Chlorophyll concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2005 summer average chlorophyll concentration in Arkdale Lake was 8.988 ug/l.**

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Arkdale Lake in 2004-2005 was 5.08'.** This is poor water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then decline as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ugm/l)	(ft)

Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	10 to 30	**5 to 10**	6 to 8
	Fair	**30 to 50**	10 to 15	**5 to 6**
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Arkdale Lake		**34.085**	**8.988**	**5.08**

According to these results, Arkdale Lake scores as **"mesotrophic"** in all three categories, with "fair" to "good" water quality and poor water clarity. This state would favor moderate plant growth and more than occasional algal blooms.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Arkdale Lake is a narrow shallow basin that gradually slopes over most of the lake. There are small areas of steeper slopes near the dam and on the southwest side of the lake. When those factors are added to the overall very shallow aspect of the lake, plant growth is highly favored in Arkdale Lake.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular lake (see Table 2).

Table 2: Sediment Composition—Arkdale Lake

Sediment Type		0-1.5'	1.5'-5'	5'-10'	% All Sites
Hard	Sand	16.67%	16.67%	25%	3.57%
	Rock	8.33%			17.86%
	Sand/Gravel		8.33%		3.57%
Mixed	Sand/Silt		8.33%	25%	7.14%
	Silt/Muck	8.33%	8.33%		7.14%
Soft	Silt	58.33%	50%	25%	50%
	Muck or Peat	8.33%	8.33%	25%	10.71%

Most of the sediment in Arkdale Lake is sand or silt or a mixture thereof (see Table 3). Although sand sediment may limit growth, sandy sites in Arkdale Lake were vegetated. Silt, which is higher in nutrients than sand, will also support vegetative growth.

Table 3: Sediment Influence in Arkdale Lake

Sediment Type		Percent All Sample Sites	Percent Vegetated
Hard	Sand	21.43%	83.50%
	Rock	3.57%	100%
	Sand/Gravel	3.57%	100%
Mixed	Sand/Silt	7.14%	100%
	Silt/Muck	3.57%	100%
Soft	Silt	53.57%	93.50%
	Muck or Peat	10.71%	100%

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Traditional cultivated lawn was the shoreline cover of the highest mean coverage (see Table 4). Other disturbed sites, such as those with rock/riprap and pavement, were also common. Of vegetated shorelines, herbaceous cover was most often found, with smaller areas of shrubs and trees also present.

Table 4: Shoreland Land Use—Arkdale Lake

Cover Type		Occurrence frequency at transects	Percent Coverage
Vegetated	Wooded	50.00%	12.03%
Shoreline	Herbaceous	100.00%	20.83%
	Shrubs	58.33%	11.25%
Disturbed	Cultivated Lawn	75.00%	38.33%
Shoreline	Hard Structures	3.33%	5.42%
	Rock/riprap/pavement	19.99%	5.04%
	Bare Sand	8.33%	7.08%

Some type of disturbed shoreline was found at 83.33% of the sites and covered 55.87% of the shoreline. Some type of vegetated shoreline was found at 100% of the sites, but only covered 44.11% of the shoreline.

<u>Macrophyte Data</u>

SPECIES PRESENT

Of the 15 species found in Arkdale Lake, 4 were emergent, 3 were free-floating, one was a floating-leaf rooted plant, and the 8 were submergent types (see Table 5). One plant-like algae, *Chara* spp. (muskgrass) was found at nearly all the sample sites. No endangered or threatened species were found. One exotic invasive, *Myriophyllum spicatum* (Eurasian Water Milfoil), was found.

Table 5—Plants Found in Arkdale Lake, 2005

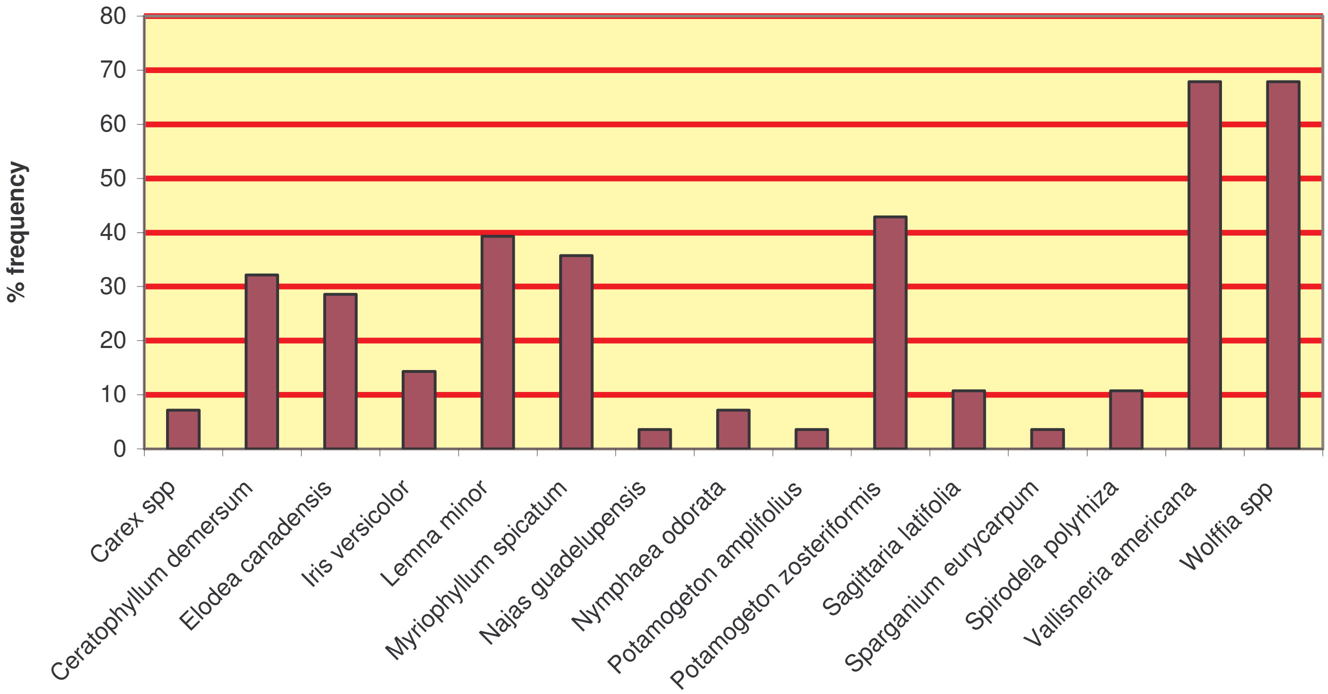
Scientific Name	**Common Name**
Emergent Species	
Carex spp	sedge
Iris versicolor	northern blue flag
Sagittaria latifolia	common arrowhead
Sparganium eurycarpum	common burreed
Free-Floating Species	
Lemna minor	small duckweed
Spirodela polyrhiza	large duckweed
Wolffia spp	watermeal
Floating-Leaf Species	
Nymphaea odorata	white water lily
Submergent Species	
Ceratophyllum demersum	coontail
Elodea canadensis	common waterweed
Myriphyllum spicatum	Eurasian watermilfoil
Najas guadelupensis	Southern naiad
Potamogeton amplifolis	large-leaf pondweed
Potamogeton zosteriformis	flatstem pondweed
Vallisneria americana	water celery
Plant-like Algae	
Chara spp	muskgrass

FREQUENCY OF OCCURRENCE

Vallisneria americana and *Wolffia* spp. were the most frequently-occurring plants in Arkdale Lake in 2005 (with 68% each). No other species reached a frequency of 50% or greater, although *Potamogeton zosteriformis* was near with 43%

frequency. (See Figure 1) *Lemna minor* and *Potamogeton zosteriformis* were abundant in the lake. *Ceratophyllum demersum, Elodea canadensis* and *Myriophyllum spicatum* were common in Arkdale Lake.

Figure 1: Species Frequency in Arkdale Lake

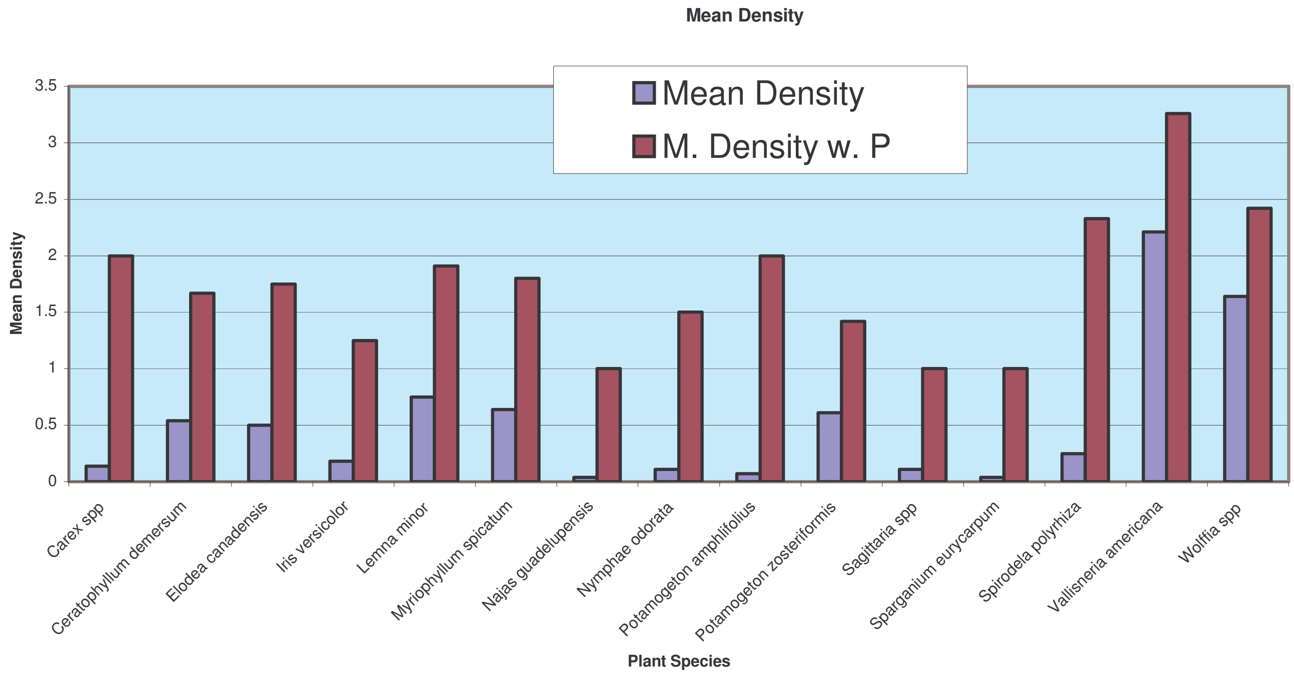


Filamentous algae was found at over 43% of the sample sites. It occurred at 42% of the 0-1.5' depth; at 50% of the 1.5'-5' depth sites; and at 50% of the 5'-10' sites. Coating of plant leaves by calcium deposits was also noted.

DENSITY OF OCCURRENCE

Vallisneria americana was also the species with the highest mean density (2.21 on a scale of 1-4) in Arkdale Lake. (See Figure 2)

Figure 2: Mean Density



Vallisneria americana had a "mean density where present" value of 3.26 and *Wofflia* spp. had a "mean density where present" of 2.42. *Spirodela* polyrhiza had a "mean density where present" value of 2.33. This means that where these plants occurred, they had a growth form above average density.

DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Vallisneria americana* was the dominant aquatic plant species in Arkdale Lake (see Figure 3). *Wolffia* spp. was sub-dominant. The exotic species found, *Myriophyllum spicatum*, did not have high dominance in the aquatic plant community.

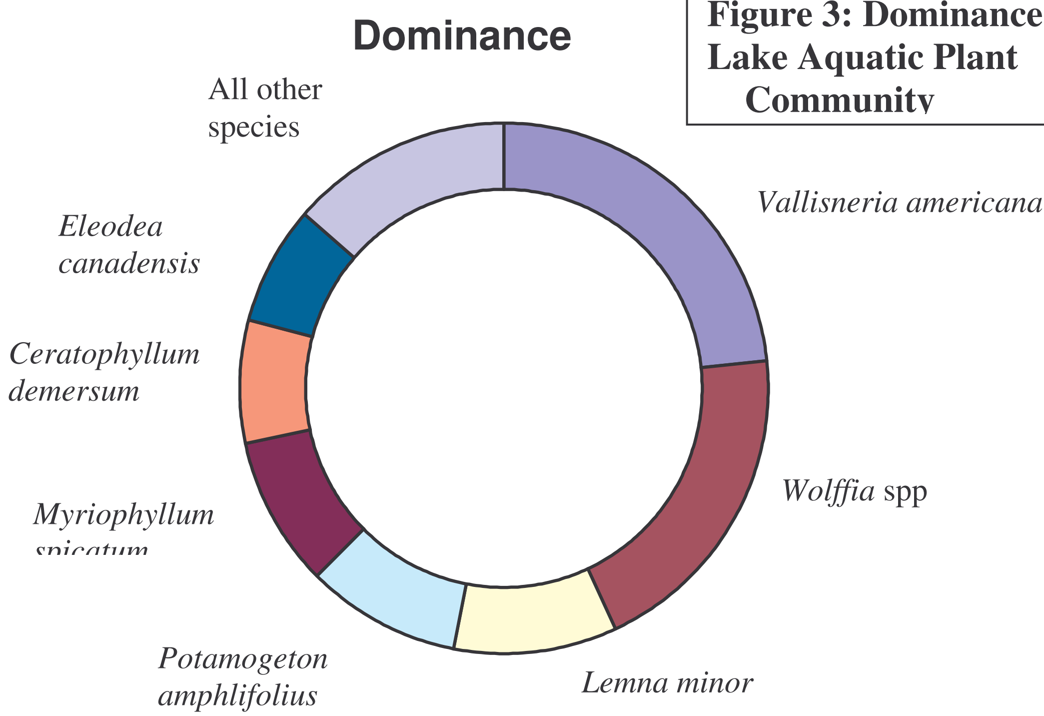


Figure 3: Dominance in Arkdale Lake Aquatic Plant Community

Both *Vallisneria americana* and *Wolffia* spp were dominant in all three depth zones. The dominance of *Vallisnerisa americana* even in the deepest zone is likely due to the overall shallowness of Arkdale Lake, with the deepest samples being taken at only 6.25’ depth. *Iris versicolor* was subdominant in the 0-1.5’ depth zone, while *Ceratophyllum demersum* and *Elodea canadensis* were subdominant in the 1.5’-5’ depth zone. *Ceratophyllum demersum* and *Myriophyllum spicatum* were subdominant in the 5’-10’ depth zone.

DISTRIBUTION

Aquatic plants occurred in nearly all of Arkdale Lake, with 89.3% of the sample sites vegetated (see Figures 4 and 5). Rooted plants were found at 6.25’, the deepest sample point. Free-floating plants were found in all three depth zones, although only

Wolffia spp was found in the deepest water. One floating-leaf plant was found in two of the depth zones. Nearly 86% of the sample sites had rooted aquatic plants.

Figure 4: Frequency of Occurrence

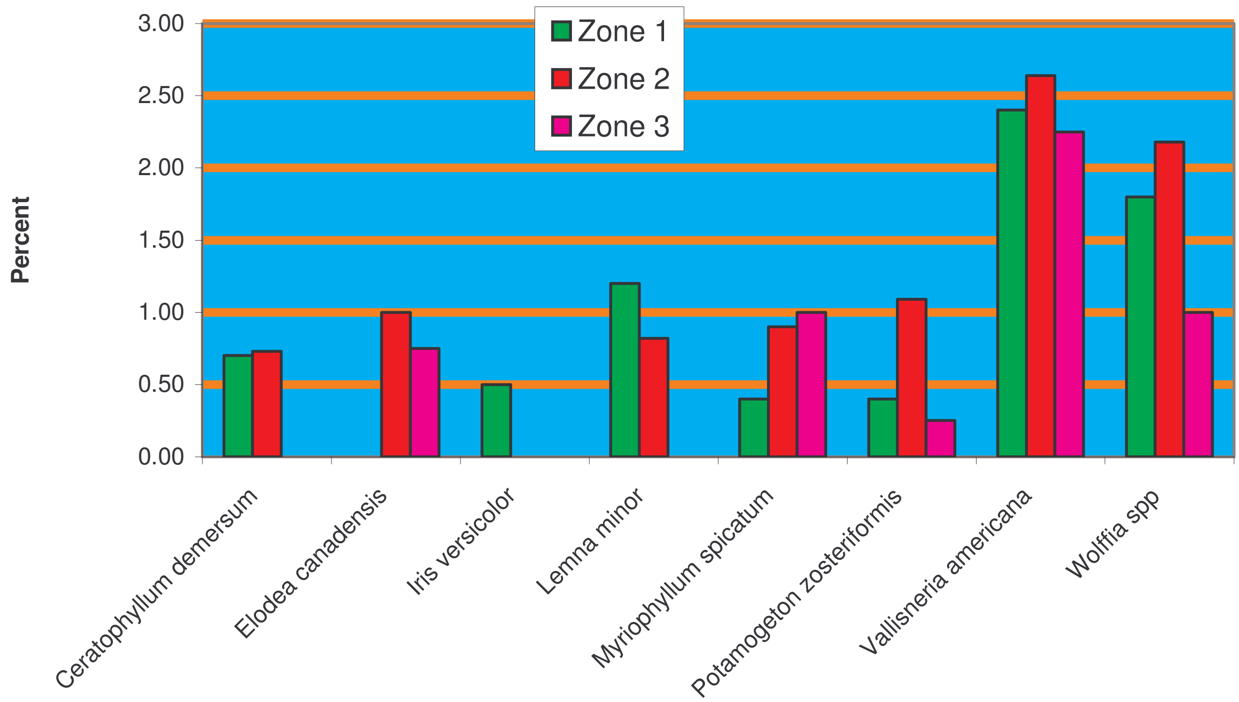
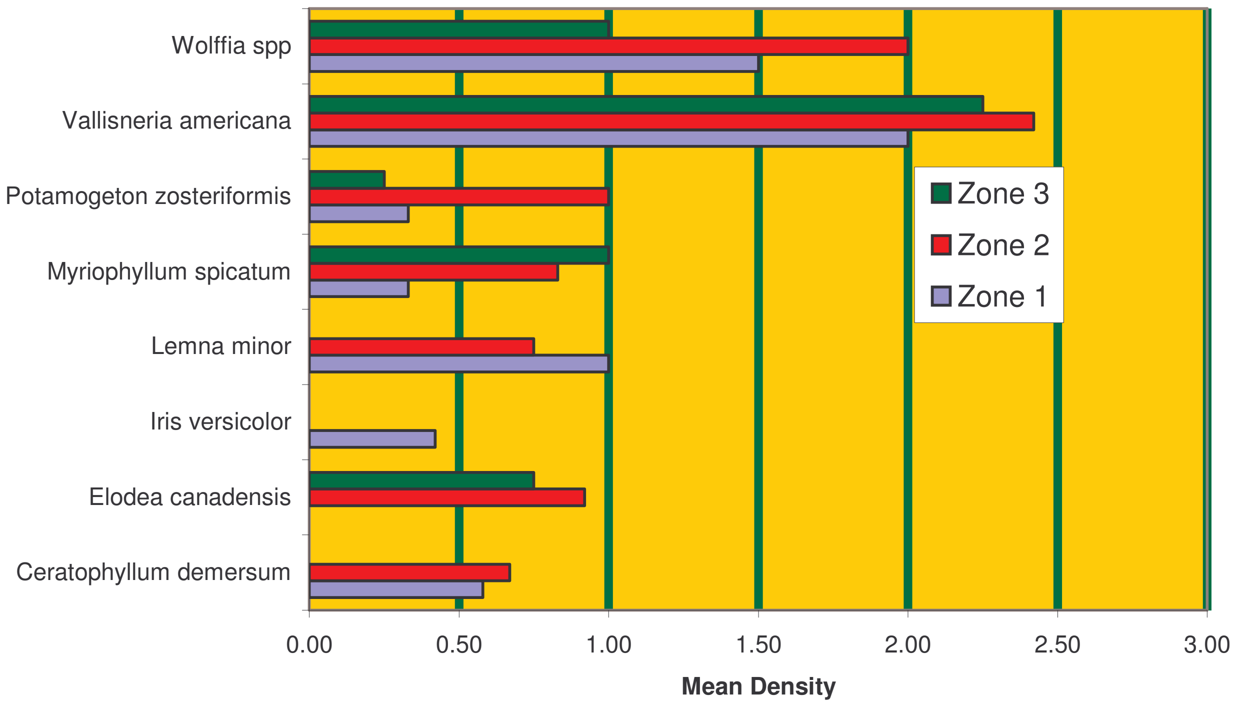


Figure 5: Density of Major Macrophytes



Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004 Secchi disc readings, the predicted maximum rooting depth in Arkdale Lake would be **8.9 feet.** The aquatic plant survey results are in agreement with this predicted depth, i.e., this calculation suggests that rooted plants at all depths would be anticipated in this lake, and rooted plants were found at all depths in Arkdale Lake.

The 1.5'-5' depth zone (Zone 2) produced the greatest amount of plant growth, with both the highest total occurrence and the highest total density occurring in this zone (see Figures 6 and 7). The 0-1.5' depth zone (Zone 1) was near Zone 2 in total occurrence and total density. Zone 3 (5'-10') recorded much lower occurrence and density.

Figure 6: Frequency of Occurrence

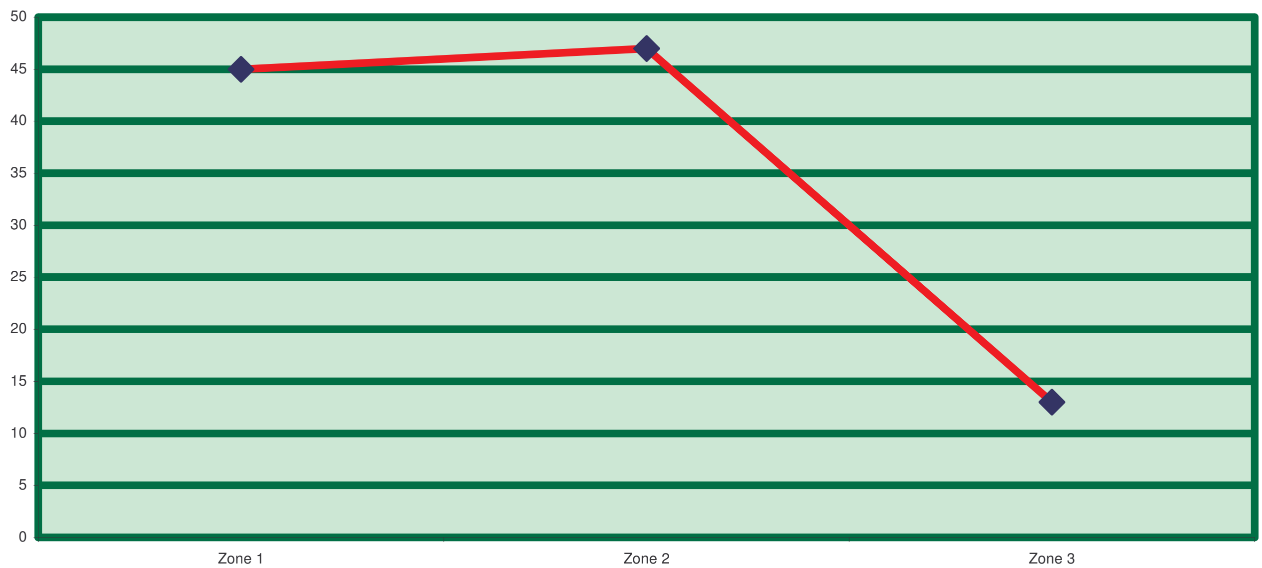
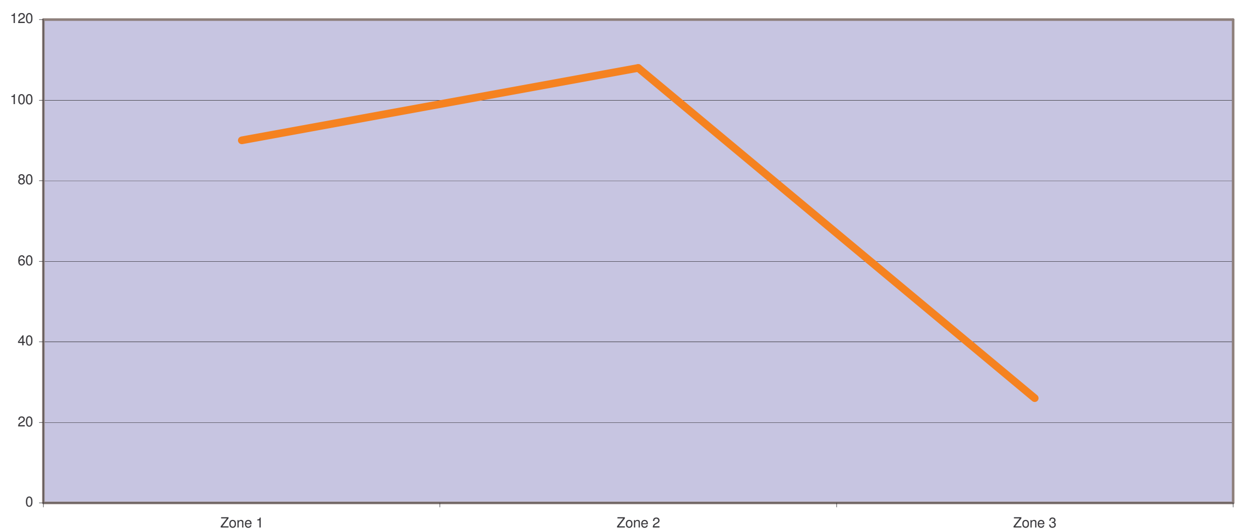


Figure 7: Density of Occurrence



83% of the sites in Zone 1 and 92% of the sites in Zone 2 (1.5'-) zone were vegetated. The greatest number of species per site (species richness) was found in Zone 2, with a 3.92 richness score, although Zone 1 (0-1.5'), with a 3.75 richness score, was only slightly lower. The 5'-10' depth zone (Zone 3) had a species richness of 3.25. Mean number of species per sampling site was 3.75.

THE COMMUNITY

The Simpson's Diversity Index for Arkdale Lake was .88, suggesting good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The Aquatic Macrophyte Community Index (AMCI) for Arkdale Lake is 53. This is in the average range for Central Wisconsin Hardwood Lakes and Impoundments.

The presence of Eurasian Watermilfoil is a significant factor. Currently, its density and relative frequency doesn't establish it as dominant among Arkdale Lake's aquatic plant community, but its tenacity and ability to spread to large areas fairly quickly make it a danger to the diversity of Arkdale Lake's aquatic plant community.

A Coefficient of Conservatism and a Floristic Index calculation were performed on the field results. Technically, the average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservation for Arkdale Lake was 4.71. This puts it in the lowest quartile for Wisconsin Lakes (6.0) and for lakes in the North Central Hardwood Region (5.6). The aquatic plant community in Arkdale Lake is in the category of those most tolerant of disturbance, probably due to selection by a series of past disturbances.

The Floristic Quality Index of the aquatic plant community in Arkdale Lake of 17.639 is below average for Wisconsin Lakes (22.2) and the North Central Hardwood Region (20.9). This indicates that the plant community in Arkdale Lake is farther from an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region. In other words, the aquatic plant community in Arkdale Lake has been impacted by a high amount of disturbance.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil found here), destruction of plant beds, or changes in aquatic wildlife can also decrease an aquatic plant community.

Apparent major disturbances to Arkdale Lake include mechanical plant harvesting, shoreline development, invasion of exotic species, deposition of sediment (especially at the east end of the lake), and fluctuating water levels.

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Arkdale Lake is a mesotrophic impoundment with poor water clarity and poor to fair water quality. This trophic state should support moderate plant growth and occasional algal blooms. The filamentous algae present at least 43% of the sites is in keeping with this trophic state and the elevated total phosphorus levels of this impoundment.

Sufficient nutrients (trophic state), shallow depth and gradually-sloped littoral zone in Arkdale Lake favor plant growth. Despite the sometime limiting effect of sand sediments on aquatic plant growth, 89.3% of the lake is vegetated, suggesting that even the sand sediments in Arkdale Lake hold sufficient nutrients to maintain aquatic plant growth.

Although mechanical harvesting has been on-going for the past few years, it has not been conducted according to any harvesting plan or schedule. Setting up a regular schedule and a harvesting map should help in removing vegetation from the lake and may somewhat help with nutrient reduction, although shallow impoundments like Arkdale Lake generally have continuous nutrient input from the watershed and creek. The harvesting should also be designed to set back the growth of Eurasian Watermilfoil, not spread it farther.

Aquatic vegetation occurred at 89.3% of the sample sites, with 86% if the sites having rooted aquatic plants. The maximum rooting depth, based on water clarity figures, is the maximum lake depth. This calculation is consistent with the field results of the plant raking in August 2005.

Both the 0-1.5' and 1.5'-5' depth zones had high relative frequency and high density of plants. The lake had only 4 sites greater than 5' deep, all of which were vegetated.

The lake does have a good mixture of emergent, floating and rooted plants. Of the 15 species record in Arkdale Lake in summer 2005, 4 were emergent, 3 were floating, 1 was floating-leaf and 9 were rooted. *Vallisnera americana* (a rooted plant) and *Wolffia* (a floating plant) were the dominant species in all depth zones. *Ceratophyllum demersum* and *Lemna* minor were subdominant in Zones 1 and 2; *Elodea canadensis* was subdominant in Zones 2 and 3. The exotic, *Myriophyllum spicatum* was subdominant in Zone 3. Three species, *Spirodela polyrhiza, Vallisneria americana* and *Wolffia* exhibited greater than average growth density.

Although *Myriophyllum spicatum* (Eurasian Watermilfoil) currently doesn't show mean density and relative frequency to establish it as dominant among Arkdale Lake's aquatic plant community. It only comprises 9% of the aquatic plant community, but is commonly occurring (36%). However, its tenacity and ability to spread to large areas fairly quickly make it a danger to the diversity of Arkdale Lake's aquatic plant community. Targeting this plant by specific plant management techniques may help keep its spread in check.

The Simpson's Diversity Index for Arkdale Lake was .88, suggesting good species diversity. However, the Aquatic Macrophyte Community Index (AMCI) for Arkdale Lake is 53 (see Table 6). This is below average for Central Wisconsin Hardwood Lakes and Impoundments, suggesting an aquatic plant community of below average quality. The 4.71 Average Coefficient of Conservation score puts Arkdale Lake in the group of lakes most tolerant of disturbance in Wisconsin lakes and lakes in the North Central Hardwood Region. The aquatic plant community in Arkdale Lake is in the category of those most tolerant of disturbance, likely from a high amount of disturbance compared to other Wisconsin lakes.

Table 6: Aquatic Macrophyte Community Index

Aquatic Macrophyte Community Index for Arkdale Lake		
Category	Arkdale Lake results	Value
Maximum rooting depth	bottom of lake	10
% littoral area vegetated	89.30%	10
%submersed plants	68%	7
% sensitive plants	21%	8
# taxa found	15 (1 exotic)	5
exotic species frequency	10%	5
Simpon's Diversity	0.88	8
total		**53**

The Floristic Quality Index of the aquatic plant community in Arkdale Lake of 17.639 is below average for Wisconsin Lakes and lakes in the North Central Hardwood Region. This indicates that the plant community in Arkdale Lake is among the group of lakes farthest from an undisturbed condition. This suggests that the aquatic plant community in Arkdale Lake has been significantly impacted by disturbance.

Traditional cultivated lawn was the most frequent shoreline cover in Arkdale Lake and also had the highest coverage. Other disturbed sites, such as those with rock/riprap and pavement, were also common. Of vegetated shorelines, herbaceous cover was most often found, with smaller areas of shrubs and trees also present. Some type of disturbed shoreline was found at 83.33% of the sites and covered 55.87% of the shoreline. These conditions offer little protection for water quality and have significant potential to negatively impact Arkdale Lake's water by increased runoff (including lawn fertilizers, pet waste, pesticides) and shore erosion. Some type of natural shoreline was found at 100% of the sites, but only protected 44.11% of the shoreline. Expanding the amount of vegetation at the shoreline, especially with wide buffers, would help prevent erosion and reduce runoff into the lake that contributes to algal growth, increased sedimentation, and reduced water quality.

V. <u>CONCLUSIONS</u>

Arkdale Lake is a mesotrophic lake with fair to good water quality and poor water clarity. Its narrow shallow basin with gradual slopes highly favor plant growth. The quality of the aquatic plant community in Arkdale Lake is below average for Wisconsin lakes and for lakes in the North Central Hardwood region, as measured by the AMCI. Structurally, it does contain emergent plants, rooted plants, floating plants and one rooted plant with floating leaves. However, the community is characterized by plants that tolerate a high amount of disturbance and abundant filamentous algae.

When the aquatic plant survey was performed, 89.3% of the lake was vegetated. The potential for plant growth at all depths of the lake is present, even though some of the lake sediments are sandy. There is likely to be on-going nutrient input into the lake from the large groundwatershed and Big Roche-a-Cri Creek, which also has a large surface watershed (see Appendix F). Although the 1.5'-5' depth zone supported the greatest plant frequency and density, the second depth zone (0-1.5') was not far behind.

The dominant plant in the lake was *Vallisneria americana* (wild celery), a rooted plant. The *Wolffia* spp. (watermeal, a floating plant) was sub-dominant. The next closest plant in abundance was *Potamogeton zosteriformis* (flat-stemmed pondweed, a rooted plant), while *Spirodela polyrhiza* (large duckweed, a floating plant) was also fairly dense. Nearly 86% of the sample sites had rooted aquatic plants, and all three depth zones had free-floating plants present.

Dominant in all three depth zones were *Vallisneria americana* and *Wolffia* spp. *Iris versicolor* (blue flag iris, a rooted plant) was sub-dominant in the 0-1.5' depth, while *Ceratophyllum demersum* (coontail, a rooted plant) and *Elodea canadensis* (common waterweed, a rooted plant) were sub-dominant in the 1.5'-5' depth zone. *Myriophyllum spicatum*, an exotic rooted plant, was sub-dominant with *Ceratophyllum demersum* in the over 5' depth zone.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

(1) Because the plant cover in the littoral zone of Arkdale Lake is over the ideal (25%-85%) coverage for balanced fishery, consideration should be given to reducing plant growth in at least some areas. A map of areas to have plants removed should be developed, then removal should occur by hand to be sure that entire plants are removed and to minimize the amount of disturbance to the settlement.

(2) Natural shoreline restoration is needed. Disturbed shorelines cover more than half of the current shoreline. A buffer area of native plants should be restored around the lake, especially on those sites that now have traditional lawns mowed to the water's edge.

(3) No lawn chemicals, especially lawn chemicals with phosphorus, should be used on properties around the lake. If they must be used, they should be used no closer than 50’ to the shore.

(4) An aquatic plant management plan should be developed with a regular schedule. Such plans will be required by the Wisconsin DNR for aquatic plant permits and grants and will also assist in reducing the frequency and density of the plants in Arkdale Lake.

(5) The schedule should include target harvesting for Eurasian Watermilfoil (EWM), although lack of water depth may require hand harvesting in some areas. Current, EWM is most frequent and most dense in the deeper depths that can be harvested mechanically.

(6) The Arkdale Lake Association should apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management.

(7) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

(8) Since the Arkdale Lake Association owns and operates the dam, consideration could be given to a cyclical winter drawdown of the lake to try to help control EWM growth. The local DNR fish biologist could assist in determining a safe winter depth for fish survival.

(9) Although Adams County Land & Water Conservation Department currently takes regular surface water samples, the program only goes through 2006. Arkdale Lake residents should get involved in the Wisconsin Self-Help Monitoring Program to permit on-going monitoring of the lake trends for basically no cost.

(10) Arkdale Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

(11) Emergent vegetation should be protected where it is currently present and re-established where it is not. These not only provide habitat, but also help stabilize the sandy shores.

(12) Sensitive areas need to be identified on the lake so that they can be protected in the future to protect diversity and habitat.

(13) If management options do not reduce the sediment and nutrient loads that are likely to be causing the excessive plant growth and continued reduced depth of the lake, the Arkdale Lake Association may consider further options. Dredging some areas to increase depth diversity and allow better boat passage is possible, although it may be expensive, and will not solve the issue if sediment input from the watershed isn't better controlled.

(14) It would also be possible to decommission the Arkdale Dam, perhaps with partial funding from the Wisconsin DNR, and remove the dam, then restore the original trout stream habitat. This would likely eliminate aquatic plant and algae problems, but would obviously change the potential of the water for recreational use. It might also increase property values for current lakefront owners.

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